CLAIMS

Having described the preferred embodiments, the invention is now claimed to be:

1. A magnetic resonance method comprising:

performing magnetic resonance imaging in a main magnetic field;

measuring spatial data corresponding to the main magnetic field; and

determining at least one main magnetic field nonuniformity parameter from the spatial data corresponding to the main magnetic field; wherein:

the measuring and determining are performed concurrently with the performing of magnetic resonance imaging.

2. The magnetic resonance method as set forth in claim 1, wherein the performing of magnetic resonance imaging comprises:

acquiring a magnetic resonance imaging repetition, frame or dynamic, the acquiring including acquiring volumetric magnetic resonance imaging data;

repeating the acquiring; and

interspersing the measuring between or concurrently with repetitions of the acquiring.

3. The magnetic resonance method as set forth in claim 1, further comprising:

acquiring a magnetic resonance imaging repetition, frame or dynamic, the acquiring including acquiring volumetric magnetic resonance imaging data;

repeating the acquiring;

computing a main magnetic field shim current based on the determined at least one main magnetic field nonuniformity parameter; and

applying the computed main magnetic field shim current during the acquiring of a subsequent magnetic resonance imaging repetition, frame or dynamic.

4. The magnetic resonance method as set forth in claim 1, further comprising:

compensating for a change in the main magnetic field by adjusting the main magnetic field based on the at least one main magnetic field nonuniformity parameter.

5. The magnetic resonance method as set forth in claim 1, further comprising:

compensating for a change in the main magnetic field by adjusting an image reconstruction of imaging data collected by the performing of magnetic resonance imaging based on the at least one main magnetic field nonuniformity parameter.

6. The magnetic resonance method as set forth in claim 1, wherein the measuring and determining comprise:

reading at least two gradient echoes using magnetic field gradients imposed along a selected direction; and

computing a nonuniformity of the main magnetic field along the selected direction from the at least two gradient echoes.

7. The magnetic resonance method as set forth in claim 6, further comprising:

repeating the reading and computing for a plurality of selected directions; and

mapping the main magnetic field based on the computed nonuniformities along the selected directions.

8. The magnetic resonance method as set forth in claim 6, wherein the reading of at least two gradient echoes comprises:

applying a balanced magnetic field gradient along the selected direction, the balanced magnetic field gradient having at least two lobes of same polarity separated by a lobe of opposite polarity; and

reading the at least two gradient echoes during the two lobes of same polarity.

9. The magnetic resonance method as set forth in claim 6, wherein the reading of at least two gradient echoes comprises:

prior to the reading of the at least two gradient echoes, applying a radio frequency excitation.

10. The magnetic resonance method as set forth in claim 9, wherein the applying of a radio frequency excitation comprises:

applying a radio frequency excitation having a low flip angle.

11. The magnetic resonance method as set forth in claim 9, further including:

reading at least two other gradient echoes using magnetic field gradients imposed along a different direction; and

wherein the readings along the selected direction and along the different direction detect magnetic resonance excited by the same said applied radio frequency excitation.

12. The magnetic resonance method as set forth in claim 6, wherein the computing comprises:

Fourier transforming each gradient echo to reconstruct a projection along the selected direction; and

computing a complex phase difference between the projections reconstructed from the at least two gradient echoes, the nonuniformity of the main magnetic field along the selected direction corresponding to the complex phase difference.

13. The magnetic resonance method as set forth in claim 12, wherein the reading of at least two gradient echoes using magnetic field gradients imposed along a selected direction comprises:

imposing the multi-lobe magnetic field gradient includes at least five lobes along the selected direction, the multi-lobe magnetic field gradient including a -a:+b:-b:+b:-a lobe area ratio where a and b represent gradient lobe areas and the positive and negative signs represent gradient lobe polarities; and

reading the at least two gradient echoes during the two +b lobes.

14. The magnetic resonance method as set forth in claim 1, wherein:

the measuring of spatial data corresponding to the main magnetic field includes reading coils of an array of spatially separated coils.

15. The magnetic resonance method as set forth in claim 14, wherein:

the performing of magnetic resonance imaging includes imaging using the array of spatially separated coils, the spatial data corresponding to the main magnetic field being extracted from the magnetic resonance imaging data.

16. The magnetic resonance method as set forth in claim 1, wherein the measuring of spatial data corresponding to a main magnetic field comprises:

exciting and sampling magnetic resonance at a resonance frequency different from the resonance frequency used in performing the magnetic resonance imaging; and

deriving spatial data corresponding to the main magnetic field from the sampled magnetic resonance.

17. The magnetic resonance method as set forth in claim 16, wherein the exciting and sampling of magnetic resonance at a resonance frequency different from the resonance frequency used in performing the magnetic resonance imaging is performed during the magnetic resonance imaging and further comprises:

sampling magnetic resonance at the resonance frequency different from the resonance frequency used in performing the magnetic resonance imaging at a plurality of spatial locations.

18. The magnetic resonance method as set forth in claim 1, wherein the measuring of spatial data corresponding to a main magnetic field comprises:

exciting and sampling magnetic resonance in an imaging subject of the magnetic resonance imaging; and

deriving spatial data corresponding to the main magnetic field from the sampled magnetic resonance.

19. A magnetic resonance imaging apparatus comprising:

a means (10) for performing magnetic resonance imaging in a main magnetic field;

a means (32, 34, 64, 66, 68, 70, 72) for measuring spatial data corresponding to the main magnetic field; and

a means (60) for determining at least one main magnetic field nonuniformity parameter from the spatial data corresponding to the main magnetic field.

20. The magnetic resonance imaging apparatus as set forth in claim 19, wherein the measuring means (32, 34, 64, 66, 68, 70, 72) comprises:

a plurality of magnetic field sensors (64, 66, 68, 70) disposed in the main magnetic field, the plurality of magnetic field sensors (64, 66, 68, 70) operating independently from the imaging means (10).

21. The magnetic resonance imaging apparatus as set forth in claim 20, wherein the magnetic field sensors (64, 66, 68, 70) are selected from a group consisting of:

Hall effect magnetic field sensors (100),

resonance-based active magnetic field sensors (80) operating at a resonance frequency different from a magnetic resonance frequency of the acquiring means, and

a plurality of field-lock coils tuned to a magnetic resonance frequency of the acquiring means.

22. The magnetic resonance imaging apparatus as set forth in claim 19, wherein the measuring means (32, 34, 64, 66, 68, 70, 72) comprises:

one or more radio frequency receive coils (32, 34) of the imaging means (10).

23. The magnetic resonance imaging apparatus as set forth in claim 19, further comprising:

a ferromagnetic structure (26) disposed in the main magnetic field, the ferromagnetic structure (26) inducing changes in the main magnetic field over time responsive to the magnetic resonance imaging.

24. The magnetic resonance imaging apparatus as set forth in claim 19, further comprising:

a means (62) for adjusting the main magnetic field during the magnetic resonance imaging based on the at least one main magnetic field nonuniformity parameter.

25. The magnetic resonance imaging apparatus as set forth in claim 19, further comprising:

a means (52) for reconstructing imaging data acquired by the means (10) for performing magnetic resonance imaging, the reconstructing means (52) adjusting the reconstructing based on the at least one main magnetic field nonuniformity parameter.

26. A magnetic resonance imaging apparatus comprising:

a magnetic resonance imaging scanner (10) performing magnetic resonance imaging, the scanner (10) including:

a main magnet (20) generating a main magnetic field,

magnetic field gradient coils (30), and

at least one radio frequency antenna (32, 34);

at least one magnetic field sensor (32, 34, 64, 66, 68, 70, 72) measuring spatial data corresponding to the main magnetic field; and

a processor (60) programmed to perform the method of claim 1 to determine the nonuniformity parameter.

27. The magnetic resonance imaging apparatus as set forth in claim 26, further comprising:

shim coils (61) for shimming the main magnetic field; and

a reconstruction processor (52);

the processor (60) being operatively connected with at least one of the shim coils (61) and the reconstruction processor (52) to adjust at least one of shim coil currents and resonance data reconstruction in accordance with the nonuniformity parameter.